



R.C.A. INSTITUTES

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Technical Lesson 52

PRACTICAL RADIO CIRCUITS - - - PART I

The circuit to be considered in this lesson bears a marked resemblance to that of Lesson 48 insofar as it incorporates a vacuum tube detector which is preceded by a stage of tuned radio-frequency amplification. The plate (output) circuit of this radio-frequency amplifier tube is coupled to the grid (input) circuit of the detector tube by a tuned radio-frequency transformer, R.F.T. 2 in Figure 1.

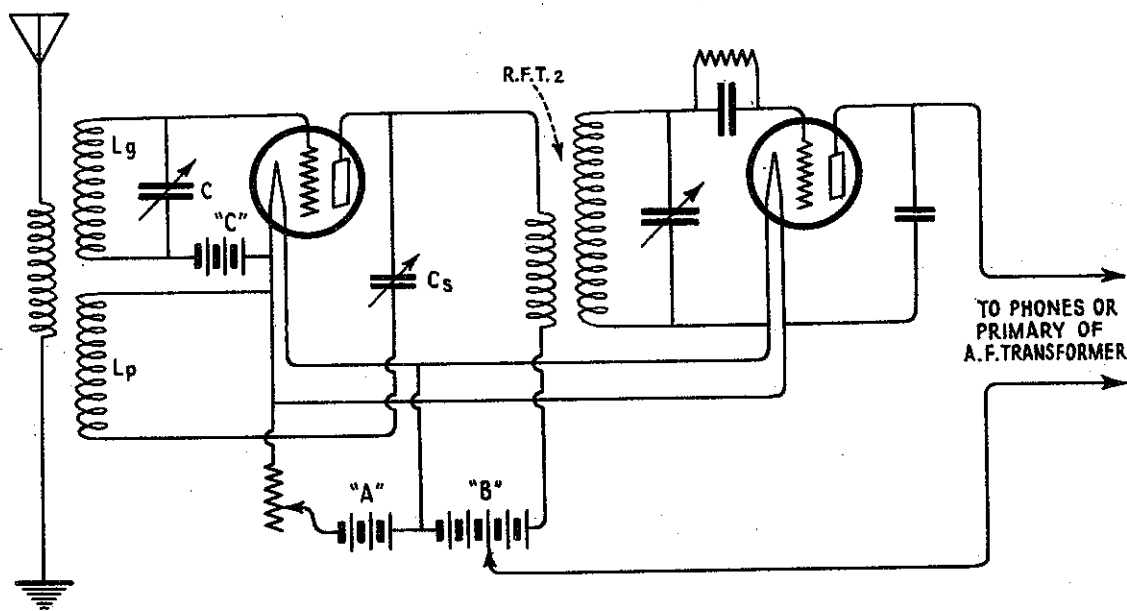


Figure 1

Furthermore, in order to secure efficient transfer of signal energy from the plate circuit of the radio-frequency amplifier tube to the tuned grid circuit of the detector tube, and in this way insure good amplification, rather tight coupling is provided between the primary and secondary windings of this transformer. Inasmuch as this is highly conducive to oscillation in the radio-frequency amplifier tube (for reasons already set forth in preceding lessons) means must be provided which will preclude the possibility of oscillation in this tube. This is accomplished, as in the preceding lesson, by adjusting the circuit to a condition of electrical balance; i.e., by stabilizing it. As in the preceding lesson, this is done by introducing into the grid circuit of the radio-frequency amplifier tube a stabilizing voltage which is equal to the troublesome feedback voltage taking place through the inherent plate-grid capacity of the tube. Moreover, this stabilizing voltage is of opposite polarity to that of the feed-back voltage and, being equal to it in strength, thus completely

counter-acts the undesirable effect of the plate-grid capacity. Inasmuch as this feed-back voltage is the cause of oscillation in the radio-frequency amplifier, counter-acting it in this manner removes the cause of oscillation, and stability of operation results.

In the circuit of this receiver, however, the method of securing this very necessary stabilizing voltage and the manner in which it is applied to the grid of the radio-frequency amplifier tube differs from the method utilized in the receiver of the preceding lesson. Although these two circuits seek to achieve the same objective; i.e., stable, non-oscillating operation of the radio-frequency amplifier tube, the manner in which this objective is attained in the circuit of this Lesson differs sufficiently from that of Lesson 48 to set it apart as a distinctive method of stabilization.

A glance at Figure 2, or Figure 3, in Lesson 48 reveals that in the receiver of that lesson the stabilizing voltage is secured by coupling the coil S to the primary P of the tuned inter-stage radio-frequency transformer. This stabilizing voltage is then applied to the grid of the radio-frequency amplifier tube through the condenser Cs, and inasmuch as this condenser is variable it enables the user to adjust the stabilizing voltage thus secured to exactly the correct value for complete stabilization. The functioning of this circuit was described in some detail in Lesson 48 and a brief summary of its method of securing and applying the stabilizing voltage may be made as follows: The stabilizing voltage is secured by inductive coupling to the plate circuit of the radio-frequency amplifier tube, and it is then applied to the grid of this tube through capacitive coupling.

Let us now turn our attention to the method of securing and applying the stabilizing voltage in the circuit used in the receiver of this lesson.

A glance at Figure 1 will reveal that this circuit incorporates the usual stage of tuned radio-frequency amplification. To this fundamental circuit has been added a small variable condenser, Cs, and a coil, Lp. This condenser and coil is to enable us to secure stabilization of the radio-frequency amplifier. It will be noted that the condenser, Cs, is connected from the plate of the radio-frequency amplifier tube to one terminal of the coil Lp, the other terminal of this coil being connected to the filament circuit. Thus, a path is provided for the flow of radio-frequency current from the plate of the radio-frequency amplifier tube through condenser Cs and coil Lp to filament.

Whenever the grid of this tube is actuated by the voltage of an incoming signal there will be a corresponding, and greatly amplified, flow of radio-frequency current in the plate circuit of this tube, and some of this amplified signal energy will flow through condenser Cs and coil Lp to filament.

As coil Lp is closely coupled to the grid coil Lg, any flow of radio-frequency current through coil Lp will result in the induction of voltages in the grid coil Lg. These voltages thus induced in coil Lg by the flow of radio-frequency current through coil Lp will, at any given instant,

be of opposite polarity to the feed-back voltage caused by the tube's plate-grid capacity.

Here, then, we have a stabilizing voltage and all that remains is to adjust it to a value equal to that of the troublesome feed-back voltage due to the tube's plate-grid capacity. This can be done by adjustment of the small variable condenser, Cs. Inasmuch as this stabilizing condenser is in series with the coil Lp its capacitive reactance, as determined by its capacity, will limit the amount of radio-frequency current flowing through coil Lp. Therefore, as the strength of the stabilizing voltage induced in the grid coil Lg is principally determined by the amount of radio-frequency current flowing in coil Lp, the stabilizing condenser, Cs, in controlling the strength of this current, serves as a means of adjusting the stabilizing voltage to the correct value; i.e., to a value equivalent to the undesirable feed-back voltage caused by the plate-grid capacity of the tube.

This description of the method employed in this circuit to secure and apply the necessary stabilizing voltage can be summed up as follows: The stabilizing voltage is obtained by capacitive coupling to the plate circuit of the radio-frequency amplifier tube and this voltage is then applied to the grid of the tube by inductive coupling - the necessary variation of this stabilizing voltage being accomplished by adjustment of the coupling capacity, Cs.

From this it can be readily appreciated that the method of securing and applying the stabilizing voltage in this circuit is quite the reverse of the method employed in the receiver of Lesson 48. In the circuit of Lesson 48 an approximately correct value of stabilizing voltage is secured by inductive coupling to the plate circuit of the radio-frequency amplifier tube. In the circuit of this Lesson the stabilizing voltage is secured by capacitive coupling to the plate circuit of the radio-frequency amplifier tube. Furthermore, in the circuit of Lesson 48 the stabilizing voltage was applied to the grid of the radio-frequency amplifier tube by capacitive coupling; whereas, in the circuit of this lesson it is applied through inductive coupling. Thus, it is apparent that stabilization in this circuit is achieved in a manner quite the opposite of that in Lesson 48.

This method of stabilizing a radio-frequency amplifier is somewhat modified in its commercial application as incorporated in manufactured receivers (such as the Radiola 20) and this change is shown in the wiring diagram of Figure 2.

The grid coil, Lg, and the plate coil, Lp, must be closely coupled and to secure this necessary closeness of coupling these two coils are wound end to end on the same winding form; as a matter of fact, they have the appearance of a single coil with a tap at the proper point for the filament connection, F. Furthermore, the tuning condenser, C, is connected across both coils and, therefore, both Lg and Lp form a part of the resonant circuit, Lg Lp C, by which it is possible to tune the input of the radio-frequency amplifier tube to the incoming signal. By thus combining coil Lp to form a part of the resonant circuit, the expense of manufacturing and installing a separate coil for Lp is saved; and inasmuch as the

coil formed by these combined plate (L_p) and grid (L_g) windings is smaller and more compact, a further economy is effected from the standpoint of conservation of space.

However, despite the fact that the plate coil, L_p , has been combined with the grid coil, L_g , to form, in conjunction with condenser C , a tuned circuit, its original purpose remains unchanged from that shown in Figure 1; namely, to introduce into the grid circuit of the radio-frequency amplifier tube a stabilizing voltage controllable by condenser C_s .

The total inductance of the coil composed of the two windings L_g and L_p is determined, in conjunction with condenser C , by the wavelength range to be covered - in this instance 200 to 550 meters. In other words, the

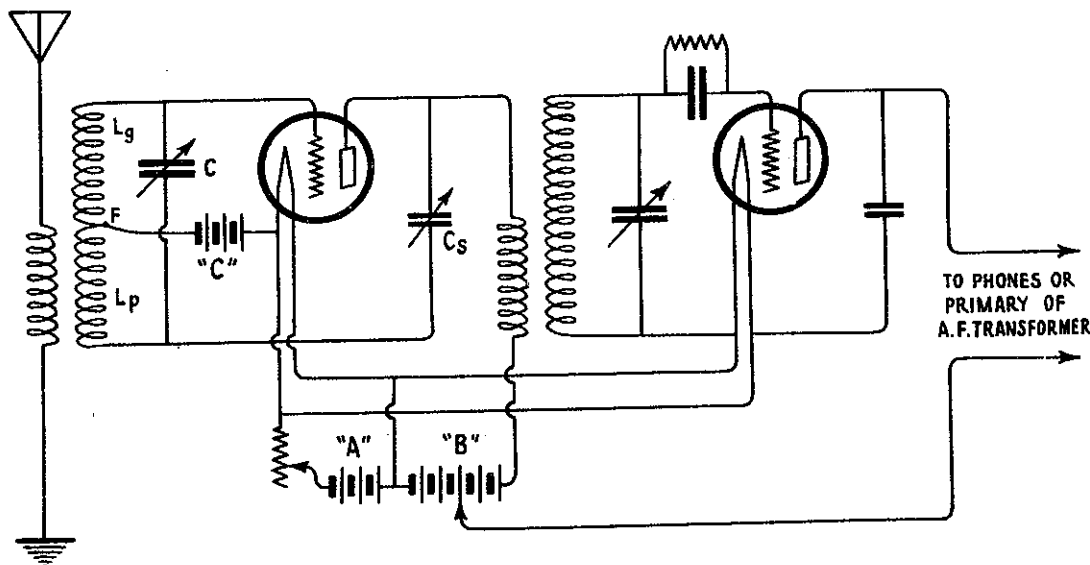


Figure 2

combined inductance of these two windings must be of such a value that when the condenser C is varied between its minimum and maximum values of capacity this circuit will be resonated to minimum and maximum wavelengths of 200 and 550 meters respectively.

With the inductance of the coil, $L_g L_p$, fixed at a definite value by such wavelength range considerations, the relative sizes of the two sections of the coil will be determined by the filament tap, F ; and, furthermore, the position of this tap will also determine the amount of capacity necessary in the stabilizing condenser, C_s , necessary to effect stabilization. Practical and theoretical considerations have shown that this tap, F , preferably should be placed at the center of the grid coil, thus making section L_p equal to section L_g . When L_p is thus made equal to L_g the radio-frequency amplifier tube can be stabilized by adjusting the capacity of the stabilizing condenser, C_s , to a value approximately equal to the plate-grid capacity of the tube.

The manner in which the relative values of L_g and L_p effect the capacity of condenser C_s is shown by the simple equation:

$$\frac{L_g}{L_p} = \frac{C_s}{C_{gp}}$$

This equation verifies the statement just made that if L_g and L_p are equal, then condenser C_s must equal the plate-grid capacity (C_{pg}) of the tube in order to secure the electrical balance necessary to prevent oscillation in the radio-frequency amplifier. According to this same equation, should the filament tap, F , be made at such a point on the coil that L_p would be, say, half as large as L_g , then it would be necessary to make the capacity of C_s twice as large as the tube's plate-grid capacity (C_{pg}) in order to secure stabilization.

The changes in the wiring of the receiver necessary to convert the circuit of Lesson 48 to that of Figure 2 in this Lesson are as follows: Trace the wire leading from the stabilizing condenser to the tap on the secondary of the three-circuit tuner - then disconnect this wire from both instruments and remove it entirely from the receiver. The stabilizing condenser is now disconnected from the grid of the radio-frequency amplifier tube and connected instead to this same tube's plate terminal.

Now let us turn our attention to radio-frequency transformer marked L_1 in the "picture" wiring diagram of Lesson 36. On the right end of this instrument are three terminals. Mark the top one number 1. At the other end of this instrument are two terminals - one of which is shown without any connection. Mark this one number 2. Trace the wire which leads from terminal number 1 on this coil to the negative "C" battery binding post. This wire should now be disconnected from the negative "C" battery binding post and connected instead to the rotor plate of the stabilizing condenser. As in the preceding Lesson only one of the two sets of stator plates in this condenser are used and this one set of stator plates should be connected to the plate terminal of the radio-frequency amplifier tube. An examination of this same radio-frequency transformer will reveal that the secondary winding is tapped at its center and that this tap is connected to the terminal now designated as number 2. A wire should now be connected from this terminal to the negative "C" battery binding post.

This completes the necessary changes in the wiring and the receiver should now be stabilized. This can be accomplished by either of the two methods described in Lesson 48. However, the method recommended is that in which the radio-frequency amplifier tube remains lighted and the stabilizing condenser adjusted while this tube is oscillating - stabilization being indicated when oscillation ceases.

PART II

The receiver with which we shall deal in this part of the lesson is one that has won widespread approval. It has been placed before the public in the form of a regularly manufactured receiver, and it has proved to be popular among amateur set builders. It has also been widely distributed in "kit" form, and in practically all quarters it has been the recipient of wholehearted endorsement and commendation. Such success is well deserved,

for this type of receiver is by no means costly to build; its construction is comparatively simple, it is sufficiently selective to meet any reasonable requirements and it is sensitive and easily handled.

This type of receiver has appeared under a variety of different names, but the circuit upon which it is based remains the same. Various individuals have used this circuit as a vehicle by which to bring their names within the spotlight of publicity, but their "achievements" have been almost invariably limited to minor variations in its design. Seldom have they displayed genuine ingenuity, and in no instance have they achieved a really important improvement upon the fundamental circuit - which incorporates a stage of tuned and stabilized radio-frequency amplification and a regenerative detector followed by two, and sometimes three, stages of audio-frequency amplification.

Like any standard circuit, this one is subject to numerous variations which make themselves evident mostly in matters of design and, in this circuit, such variations often make themselves evident in the manner in which the basic principle of stabilization is applied to the stage of tuned radio-frequency amplification. In the receiver of this part of the Lesson the stage of tuned radio-frequency amplification is stabilized in a manner differing somewhat from the methods previously described.

In Figure 3 is shown the basic circuit of this method of applying stabilization to the radio-frequency amplifier tube. Stabilization is secured by means of the small variable condenser, Cs, and the coil, Lp. The functioning of this coil and condenser is very similar to the corresponding coil and condenser in Figure 1, as will be evident from the following consideration. A part of the radio-frequency current flowing in the plate circuit of the radio-frequency amplifier tube will be diverted through condenser Cs and thence will flow through coil Lp. This coil is closely coupled to coil Lg and therefore the radio-frequency current flowing through coil Lp will induce in coil Lg voltages which are suitable to stabilizing purposes. Inasmuch as condenser Cs is variable it serves to control the amount of radio-frequency current flowing through coil Lp and in this way regulates the amount of stabilizing voltage induced in coil Lg. Therefore, by properly adjusting the value of capacity of condenser Cs this stabilizing voltage can be regulated to just the right value to completely suppress oscillation in the radio-frequency amplifier tube.

It is not at all necessary to employ a separate coil for winding Lp; as a matter of fact, a portion of the winding Lg may be used for this purpose, as shown in Figure 4.

Making the winding Lp a part of coil Lg, and thus combining the two coils into one, does not in the least change the functioning of winding Lp. Radio-frequency current flowing through winding Lp induces in winding Lg a stabilizing voltage which is regulated to the correct value by adjustment of condenser Cs. In the actual coil used in this receiver the coil is divided into sections Lg and Lp by a tap taken off at the center of the winding.

It will now be necessary to again refer to the "picture" diagram of Lesson

36. Therein this coil is shown as coil L1, and terminal number 2 is the mid-tap of the winding (the terminals of this coil being numbered in accordance with the directions on sheet 5, paragraph 4, of this lesson).

The changes in the wiring of the preceding receiver which are necessary to convert it to the present circuit are as follows: The stator plates of the stabilizing condenser, Cs, remain connected to the plate of the radio-frequency amplifier tube, but the wire which is connected to the stator plate of this condenser should be disconnected therefrom and be connected instead to the negative "C" battery binding post. The wire which leads from the mid-tap (terminal number 2) on coil L1 to the negative

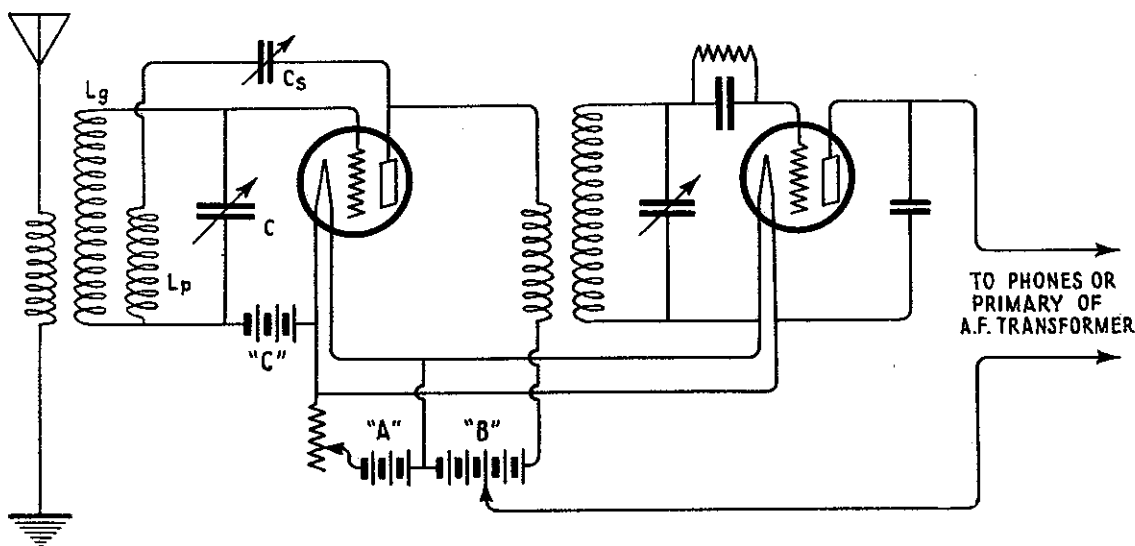


Figure 3

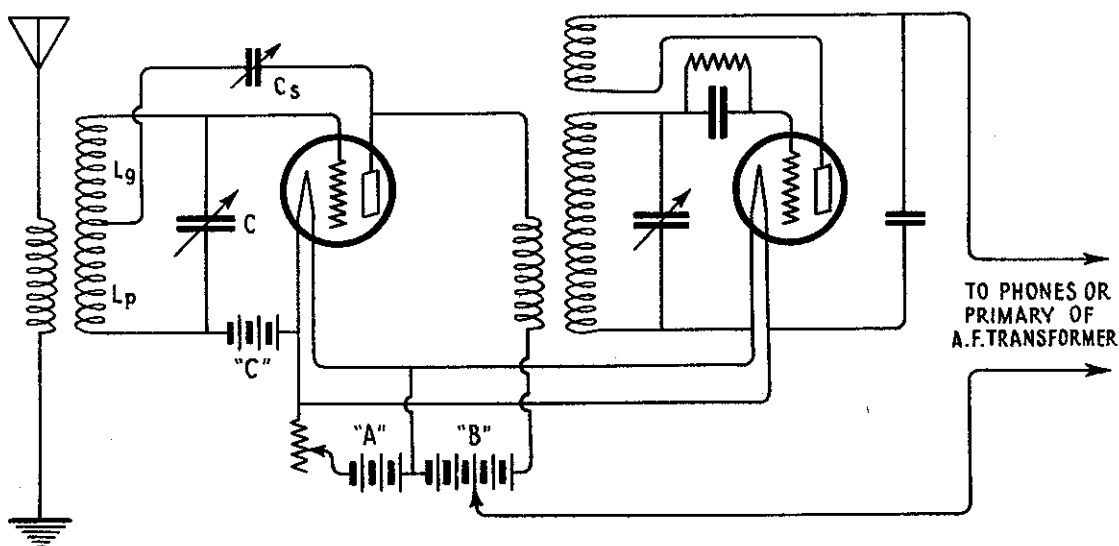


Figure 4

"C" battery binding post should be disconnected from this binding post and connected instead to the rotor plate of the stabilizing condenser. The tickler coil should now be connected into the plate circuit of the detector tube. This is done by disconnecting the wire attached to the plate terminal of the detector tube socket and connecting it instead to one of the tickler coil terminals on the upper end of the three-circuit tuner. A wire is now connected from the other tickler coil terminal to the plate terminal of the detector tube socket.

The receiver is now ready to be stabilized and this is done in the manner described in preceding lessons. Briefly, a station is tuned in on the receiver and the stabilizing condenser, Cs, is carefully adjusted until the squeal, which is caused by oscillation in the radio-frequency amplifier, disappears.

This receiver possesses a very desirable advantage in that it does not radiate even though the detector tube is oscillating. (See Lesson 32, sheet 5, paragraphs 1 to 5). In any receiver, if a tube which is coupled either directly or indirectly to the antenna is allowed to oscillate, some of this oscillatory current will be transferred to the antenna by this coupling between it and the oscillating tube, and the radio-frequency current thus introduced into the antenna will result in the radiation of a weak radio wave.

This can be overcome by employing a stage of properly stabilized radio-frequency amplification between the antenna and the tube which is liable to oscillate (the detector tube in this instance). That this is so is evident when one stops to consider that stabilization is the electrical balancing of the radio-frequency amplifier circuit in order to prevent excessive feed-back of radio-frequency (oscillatory) energy from the plate to the grid circuit. Once this state of electrical balance has been secured it will prevent feed-back from the plate circuit to the grid circuit of the radio-frequency amplifier tube, and it will be equally as effective against oscillatory current produced by an oscillating detector tube to which the plate circuit of the stabilized radio-frequency amplifier tube is coupled.

Although the radio wave radiated from an oscillating receiving tube is weak it can, nevertheless, cause serious interference with other receivers over a considerable area. Thus, it can be readily appreciated that it is a decided, and highly desirable, advantage to block such oscillatory current from reaching the antenna especially in thickly populated districts where large numbers of receivers are found within comparatively small areas.

EXAMINATION - LESSON 52

1. Why is stabilization necessary?
2. What should be the strength of the stabilizing voltage as compared to the strength of the feed-back voltage due to the tube's plate-grid capacity?
3. Referring to Figure 1, what is the purpose of coil L_p ?
4. What should be the polarity of the stabilizing voltage as related to the feed-back voltage due to the tube's plate-grid capacity?
5. How is the strength of the stabilizing voltage adjusted to the correct value in the circuit of Figure 2?
6. Describe briefly a method of adjusting a receiver in order to stabilize it.
7. Is the detector tube in Figure 3 regenerative or non-regenerative? Why?
8. Referring to Figures 1 and 2, what is the advantage of combining coils L_p and L_g ?
9. How is regeneration secured in the circuit of Figure 4?
10. What is the advantage of employing a stage of stabilized radio-frequency amplification ahead of a detector which may possibly oscillate?